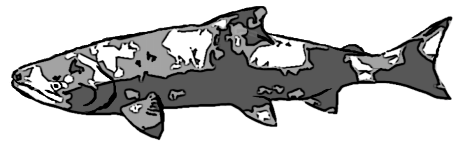
Part One
Life History and Stock Assessment



1.1 Introduction

This chapter provides a summary of summer chum salmon life history, an overview of summer chum current status, a review and recalculation of escapement and run size data, and formal evaluations of current status and risk for summer chum stocks. Because having the best possible summer chum salmon data is critical for all elements of this recovery plan, the existing escapement, run size, and age data for summer chum salmon are reviewed below, and newly up-dated escapement and run size data bases are provided. The status review provides new assessments of summer chum stocks and their current status at the time of publication. This stock information will be used in the initiative to identify the population units that will form the basis of recovery planning. Two separate approaches are included for assessing risk, and these evaluations will be used throughout the process to help prioritize recovery actions.

1.2 Background

The following is a brief overview of the current status of summer chum salmon. More detailed discussions of summer chum status are provided in the following sections of this chapter.

Summer chum of the Hood Canal and Strait of Juan de Fuca region are defined as those fish that have an average peak of spawning before November 1. These fish have declined in the recent past to critically low total adult return and escapement levels. Although the area and timing of spawning ground surveys has varied, particularly in the early survey years, it is evident that spawner returns to production streams have fallen from combined escapements of up to tens of thousands to less than a thousand, with a low of 770 spawners in 1990. Over the last few years, however, there has been an increasing trend in overall escapement.

The 1992 Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993) describes the majority of the populations of summer chum in the Hood Canal/SJF region as being of critical status; that is, "experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred". Chronically low escapements are the reason for the critical status ranking. Two populations are not described as critical; the Union River population, which is rated healthy, and the Jimmycomelately Creek population which is described as depressed. The Dungeness River is not included in the 1993 inventory as currently supporting a summer chum population, however, a subsequent analysis of spawning ground counts indicates that summer chum may be present in the river.

The generally critical status of the Hood Canal summer chum is heightened by the recent loss of populations in a number of production streams historically utilized for spawning. Of at least fifteen streams that have historically produced annual returns of summer chum, seven are now considered to no longer support summer chum salmon.

The National Marine Fisheries Service listed summer chum in the Hood Canal and Strait of Juan de Fuca Evolutionarily Significant Unit (ESU) as a threatened species in March of 1999.

1.3 Summer Chum Salmon Life History

While much of the following life history summary is based on specific information about summer chum salmon, some of the descriptive material is derived from observations made on fall chum salmon.

1.3.1 Description and Distribution

1.3.1.1 Description

Adult chum salmon and sockeye salmon are distinguished from other Pacific salmon by a lack of distinct black spots on the back and caudal fin. The 19 or 20 short, stout gill rakers on the first arch of the chum salmon distinguish it from sockeye, which have 28 to 40 long, slender gillrakers (Wydoski and Whitney 1979). Juvenile chum salmon are distinguished by parr marks of relatively regular height that are smaller than the vertical diameter of the eye, and that are faint or absent below the lateral line (McConnell and Snyder, undated). When in spawning condition, adult chum salmon have greenish to dusky mottling on the sides, with males exhibiting distinctive reddish-purple vertical barring. Adult chum in Puget Sound range in size from 17 to 38 inches, with an average weight of 9 to 11 pounds.

Summer Chum Salmon

The earliest returning chum salmon (Onchorynchus keta) stocks in the Hood Canal and Strait of Juan de Fuca region. Summer chum salmon return from the ocean from mid-August through October, and spawn predominately in September and October. These stocks have been shown to be genetically distinct from fall and winter timed chum salmon.

One distinguishing characteristic of this group of summer chum populations is an early nearshore marine area, adult run timing (early August into October). This early timing creates a temporal separation from the more abundant indigenous fall chum stocks which spawn in the same area, allowing for reproductive isolation between summer and fall chum stocks in the region (WDF et al. 1993). The distance between summer chum spawning tributaries of Hood Canal and the eastern

Strait of Juan de Fuca, and the rest of the Puget Sound streams, creates a geographical separation among the stocks.

Hood Canal and Strait of Juan de Fuca summer chum populations are one of three genetically distinct lineages of chum salmon in the Pacific Northwest region (Johnson et al. 1997). WDFW has concluded that the Hood Canal and Strait of Juan de Fuca summer chum comprise a distinct major ancestral lineage, defined as stocks whose shared genetic characteristics suggest a distant common ancestry, and substantial reproductive isolation from other chum lineages (Phelps et al.1995, WDFW 1995). NMFS (Johnson et al. 1997) has designated Hood Canal and Strait of Juan de Fuca summer chum as an evolutionarily significant unit, based upon distinctive life history and genetic traits. Genetic differences between summer chum and all other chum stocks in the U.S. and British Columbia are a result of long-standing reproductive isolation of the Hood Canal and Strait of Juan de Fuca summer chum populations (Tynan 1992). This isolation has been afforded by a significantly different migration and escapement timing, and geographic separation from other chum stocks in the Pacific Northwest (Tynan 1992, Johnson et al. 1997).

1.3.1.2 Distribution

A total of 11 streams in Hood Canal have been identified as recently having indigenous summer chum populations : Big Quilcene River, Little Quilcene River, Dosewallips River, Duckabush River, Hamma Hamma River, Lilliwaup River, Union River, Tahuya River, Dewatto River, Anderson Creek, and Big Beef Creek (Tynan 1992). Summer chum are occasionally observed in other Hood Canal drainages, including the Skokomish River which was once a major summer chum stream. SASSI (WDF et al. 1993) lists two, distinct summer chum populations in Hood Canal - the Union River population and a group including all other Hood Canal summer production streams, but this assessment has been modified for this recovery plan (see 1.7.2 Stock Definition and Status below).

Summer chum salmon populations in the eastern Strait of Juan de Fuca occur in Snow and Salmon creeks in Discovery Bay and Jimmycomelately Creek in Sequim Bay and have been reported in Chimacum Creek, located near Port Hadlock in Admiralty Inlet (WDF et al. 1993, Sele 1995). Recent stock assessment data indicate that summer chum also return to the Dungeness River, but the magnitude of returns is unknown (Sele 1995).

Summer chum in the region use Hood Canal and the Strait of Juan de Fuca estuarine and marine areas for rearing and seaward migration as juveniles. The fish spend two to four years in northeast Pacific Ocean feeding areas prior to migrating southward during the summer months as maturing adults along the coasts of Alaska and British Columbia in returning to their natal streams. Adults may delay migration in extreme terminal marine areas for up to several weeks before entering the streams to spawn. Spawning occurs in the lower reaches of each summer chum stream.

1.3.2 Life History Strategy

Summer chum have evolved to exploit freshwater and estuarine habitats during periods, and for durations, when interaction with other Pacific salmon species and races is minimized. The uniqueness of summer chum is best characterized by their late summer entry into freshwater spawning areas, and their late winter/early spring arrival in the estuaries as seaward-migrating juveniles.

Summer chum spawning occurs from late August through late October, generally within the lowest one to two miles of the tributaries. Depending upon temperature regimes in spawning streams, eggs reach the eyed stage after approximately 4-6 weeks of incubation in the redds, and hatching occurs approximately 8 weeks after spawning (L. Telles, Quilcene National Fish Hatchery, Quilcene, WA, pers. comm., 1996). Alevins develop in the redds for additional 10-12 weeks before emerging as fry between February and the last week of May. Estimated peak emergence timings for Hood Canal and Strait of Juan de Fuca summer chum populations are March 22 and April 4 respectively. By contrast, indigenous fall chum stocks spawn in Hood Canal streams predominately in November and December, and the resulting fry emerge from the spawning gravels approximately one month later than summer chum salmon, between late April and mid-May (Koski 1975, Tynan 1997). Chum fry recovered in Hood Canal marine areas during the summer chum emergence period range in size from 35-44 mm.

1.3.3 Freshwater Juvenile Life History

1.3.3.1 Incubation

Developing chum salmon incubate as eggs or sac fry in the gravel for five or six months after fertilization, a time period determined mainly by ambient temperature regimes characteristic of Pacific Northwest streams (Bakkala 1970, Koski 1975, Schreiner 1977, Salo 1991). Stream flow, dissolved oxygen levels, gravel composition, spawning time, spawning density and genetic characteristics also affect the rate of egg/alevin development, and hence gravel residence time (Bakkala 1970, Koski 1975, Schroder 1981, Salo 1991). The earliest eggs deposited enter the tender stage starting the first week in September, with the majority of incubating eggs reaching the eyed stage by November 3. Bakkala (1970) reports total gravel residence times for chum ranging from 78 to 183 days across the range of chum salmon distribution, dependent on stream temperature. Koski (1975) has documented an average gravel residence time from spawning to 50% (peak) population emergence for Big Beef Creek summer chum of 166 days, with 95 % emergence after 177 days. Telles (1996) reports 100 % emergence (swim-up) of 1994 brood Big Quilcene River summer chum 111 days after fertilization at QNFH.

1.3.3.2 Emergence and Downstream Migration

Summer chum fry emergence timing in Hood Canal can range from the first week in February (“warm” years and/or earlier spawn date years) through the second week in April (colder and/or later spawn date years). The 10 %, 50 % and 90 % average emergence dates across years reported for Big Beef Creek summer chum are March 13, March 18, and March 27, respectively (Tynan 1997). The 10 % to 90 % emergence range observed across years is February 7 through April 14. Strait of Juan de Fuca summer chum generally emerge later than Hood Canal summers due to colder stream incubation temperatures. Estimated, average 10%, 50%, and 90% emergence dates for Strait of Juan de Fuca summer chum are March 6, April 4, and April 26, respectively. The 10% to 90% emergence range estimated across years for Strait chum is February 15 through May 26 (Tynan 1997).

Fry emerge with darkness, and immediately commence migration downstream to estuarine areas (Bakkala 1970, Koski 1975, Schreiner 1977, Koski 1981, Salo 1991), with total brood year migration from freshwater ending within 30 days for smaller streams and rivers (Salo 1991). Emerging chum fry have been shown to become very active with darkness (Hoar 1951), preferring the swiftest areas of downstream flow and exhibiting strong negative rheotaxis, often swimming more rapidly than the current (Hoar 1951, Neave 1955).

1.3.4 Estuarine and Marine Life History

1.3.4.1 Estuarine Behavior

Upon arrival in the estuary, chum salmon fry inhabit nearshore areas (Schreiner 1977, Bax 1982, Bax 1983, Whitmus 1985). Chum fry have a preferred depth of between 1.5-5.0 meters at this time (Allen 1974) and are thought to be concentrated in the top few meters of the water column both day and night (Bax 1983b). In Puget Sound, chum fry have been observed through annual estuarine area fry surveys to reside for their first few weeks in the top 2-3 centimeters of surface waters and extremely close to the shoreline (Ron Egan, WDFW, Olympia, WA, pers. comm.). Iwata (1982) reports that, in Japan, chum are located in stratified surface waters (20-100 cm depth) upon arrival in the estuary, showing a very strong preference for lower salinity water (10 to 14 ppt) found above the freshwater/saltwater interface, perhaps as a seawater acclimation mechanism. This nearshore and surface behavior could also be linked to survival, as small size exposes youngest fry to heavy predation. Onshore location may protect the fry from larger fish (Gerke and Kaczynski 1972, Schreiner 1977) and schooling behavior may be an adaptation to predator avoidance (Feller 1974).

Chum fry arriving in the Hood Canal estuary are initially widely dispersed (Bax 1982), but form loose aggregations oriented to the shoreline within a few days (Schreiner 1977, Bax 1983, Whitmus, 1985). These aggregations occur in daylight hours only, and tend to break up after dark (Feller 1974), regrouping nearshore at dawn the following morning (Schreiner 1977, Bax 1983). Bax et al. (1978) report that chum fry at this initial stage of out-migration use areas predominately close to shore. “Early run” chum fry in Hood Canal (defined as chum juveniles migrating during February and March) usually occupy sublittoral seagrass beds with residence time of about one week (Wissmar and Simenstad 1980). Schreiner (1977) reports that Hood Canal chum maintain a nearshore distribution until they reach a size of 45-50 mm, at which time they move to deeper off-shore areas.

1.3.4.2 Food

Chum fry captured in nearshore environments during out-migration in upper Hood Canal are found to prey predominantly on epibenthic organisms, mainly harpacticoid copepods and gammarid amphipods (Bax et al. 1978, Simenstad et al. 1980). Diet changes to predominantly pelagic organisms in early May for fry migrating in off-shore areas. Dabob Bay chum fry are reported to feed continuously (day and night) in using nearshore areas as a source of food (Feller 1974). Feller (1974) and Gerke and Kaczynski (1972) have documented initial preference (and predominance in the diet) of epibenthic prey by chum fry in Dabob Bay, followed by a gradual switch to pelagic prey as time progressed. Several researchers have documented a reliance on drift insects by migrating chum fry in British Columbia (Mason 1974) and in Dabob Bay, Hood Canal (Gerke and Kaczynski 1972). Hatchery-released chum fry in southern Hood Canal are found initially to prey almost exclusively on terrestrial insects, likely made available as drift from the Skokomish River (Whitmus 1985). Faster-migrating fry that have moved further north of the Skokomish delta are found to feed entirely on neritic and epibenthic organisms. Simenstad et al. (1980) show a gradual decrease in the epibenthic fraction of stomach contents as the chum increase in size. Migration off-shore could result from opportunistic movement of fry to take advantage of larger, more prevalent prey organisms in the neritic environment (Bax 1983).

1.3.4.3 Juvenile Seaward Migration

Upon reaching a threshold size (~ 50 mm), summer chum entering the estuary are thought to immediately commence migration seaward, migrating at a rate of 7 - 14 km/day (Tynan 1997). Rapid seaward movement may reflect either "active" migration in response to low food availability or predator avoidance, or "passive" migration, brought on by strong, prevailing south/southwest weather systems that accelerate surface flows and move migrating fry northward (Bax et al. 1978, Simenstad et al. 1980, Bax 1982, Bax 1983). Assuming a migration speed of 7 km/day, the southernmost out-migrating fry population in Hood Canal would exit the Canal 14 days after entering seawater, with 90 % of the annual population exiting by April 28 each year, on average. Applying the same migration speed, summer chum fry originating in Strait of Juan de Fuca streams would exit the Discovery Bay region 13 days after entering seawater, or by June 8 each year (90 % completion).

1.3.4.4 Ocean Migration

After two to four years of rearing in the northeast Pacific Ocean, maturing Puget Sound-origin chum salmon follow a southerly migration path parallel to the coastlines of southeast Alaska and British Columbia (Neave et al. 1976, Salo 1991, Myers 1993). The precise timing of this migration from Gulf of Alaska waters for Hood Canal summer chum is unknown. Genetic stock identification data collected from Canadian Strait of Juan de Fuca commercial net fisheries (LeClair 1995, 1996), Canadian fishery recoveries in 1995 of coded wire tagged Big Quilcene summers (PSMFC data, August 14, 1996) and a single recovery in Big Beef Creek of a summer chum tagged in a southeast Alaska ocean fishery study (Koski 1975), suggest that the southerly ocean migration down the Pacific Northwest coast and into the Strait of Juan de Fuca likely commences in mid-July, and continues through at least early September. Migrational timing of Strait of Juan de Fuca summer chum into Washington marine waters appears earlier than arrival timing observed for Hood Canal summer chum. The stocks in this region enter the terminal area (the Strait) from the first week of July through September (WDFW and WWTIT 1994). GSI data collected from Canadian net fisheries at the entrance to the Strait suggests that Hood Canal and Strait of Juan de Fuca summer chum are present through August and into early September (LeClair 1995, 1996).

1.3.4.5 Adult Nearshore Migration

Summer chum mature primarily at 3 and 4 years of age with low numbers returning at age 5 (there are rare observations of age 2- and 6-year fish). They enter the Hood Canal terminal area from early August through the end of September (WDFW and WWTIT 1994). Entry pattern data for Quilcene Bay provided by Lampsakis (1994) suggest that summer chum enter extreme terminal marine areas adjacent to natal streams from the third week in August, through the first week in October, with a central 80% run timing of August 30 through September 28, and a peak on September 16.

Comparison of extreme terminal area entry timing in Quilcene Bay with spawning ground timing estimates developed from Big Quilcene River data, suggests that summer chum may mill in front of their stream of origin for up to ten to twelve days before entering freshwater (with shorter milling times later in the run). Thus, it is assumed that summer chum observed on spawning grounds entered the river five days earlier, based on a ten day average survey life (Appendix Report 1.2). This behavior is likely related to the amount of time required for the chum to complete maturation and to acclimate to freshwater, but is also affected by available stream flows.

1.3.5 Adult Freshwater Migration and Spawning

1.3.5.1 River Entry

Spawning ground entry timing in Hood Canal ranges from late August through mid-October. Lampsakis (1994) reports a central 80 % spawning ground timing in the Big Quilcene River of September 11 through October 14, with a peak on or about September 28, based on 22 years of spawning ground survey data. Strait of Juan de Fuca summer chum begin spawning during the first week of September, reaching completion in mid-October (WDFW and WWTIT 1994). Time density analysis of Snow, Salmon and Jimmycomelately creeks' spawner survey data for the lower portions of the drainages indicates a central 80 % spawning ground timing of September 16 through October 20, with an average peak on October 2 (Lampsakis 1994). For more detailed discussion of timing see Appendix Report 1.2.

1.3.5.2 Spawning

Hood Canal summer chum typically spawn soon after entering freshwater in the lowest reaches of natal streams (Koski 1975, Schroder 1977, Johnson et al. 1997). This characteristic may reflect an adaptation to low flows present during their late summer/early fall spawning ground migration timing, which confine spawning to areas with sufficient water volume. Spawning in lower river reaches during low flows, however, confines incubating eggs to center channel areas, exposing the eggs to increased risk of egg pocket scouring during freshets. Koski (1975) notes that Big Beef Creek summer chum spawning takes place predominantly in the lower 0.8 km of stream. Cederholm (1972) reports that 100 % of the summer chum run to Big Beef Creek in 1966 and 1967 spawned in the lower 0.6 km of the creek. WDFW documentation of summer chum spawning in the Big Quilcene River indicates that 90% of spawning occurs in the lower mile of the 2.2 miles of river accessible to salmonids. Summer chum spawn in the lower mile of Salmon Creek and in the lower one-half mile of Snow and Jimmycomelately creeks (WDFW and WWTIT 1994). As with Hood Canal summer chum, low summer-time flows likely have acted to confine summer chum spawning in this region to the lowest reaches of each production stream.

1.4 Summer Chum Salmon Data

1.4.1 Introduction

The overall quality of the data available to evaluate the possible factors responsible for the decline of summer chum salmon in Hood Canal and the Strait of Juan de Fuca will impose limitations on the ability to understand the exact nature of the problem. Ideally, survival data for individual broods and individual spawning populations would be used to measure the impacts of potential factors limiting production. In the case of these summer chum stocks, however, some of the data needed to calculate survival rates is either missing or is only sporadically available.

1.4.2 Escapement Data

An important source of information for the management of summer chum salmon (or any other salmon species) is the numbers of mature fish escaping all sources of prior mortality to successfully spawn in their natal streams. The numbers of spawning fish provide: 1) a measure of the status of populations, 2) a way to determine the impacts of fisheries and other mortality agents, and 3) a primary element used in predicting future run sizes. The quality of summer chum salmon escapement estimates has varied over the years, primarily because of changes in the amount of effort expended to count spawners.

Escapement

The number of adult fish returning to a stream that escape mortality from harvest and natural attrition, and comprise a spawning population.

1.4.2.1 Historical Estimates

Spawning ground counts of Hood Canal and the Strait of Juan de Fuca summer chum salmon were conducted at least since 1943, when 0.8 stream miles were surveyed during the time of year when summer chum spawn. Since then, survey effort increased in several stages, driven by the increasing need for better management information. Only a handful of counts were made up to 1952, when a system of standardized index areas was implemented by WDF to monitor the escapement of all species of salmon in Puget Sound streams. Summer chum salmon spawner survey effort in Hood Canal and Strait of Juan de Fuca streams averaged a modest seven miles per year between 1952 and 1963. An increased emphasis was placed on monitoring both pink and chum salmon in the mid-1960s, with the result that summer chum surveys in the region doubled for the 1964-1973 period, to an average of 14 miles surveyed per year. During these early years of counts in index streams (1952-1973), escapements were evaluated by comparing the relative annual changes in peak live and dead spawner abundance (WDF et al. 1974). This approach to monitoring escapements did not require an intensive survey schedule; usually the peak abundance was counted with between one and three surveys of each stream. One negative result of this survey methodology was that not all summer chum spawning streams were surveyed every year.

The 1974 Boldt Decision imposed the need for more accurate escapement numbers. There was an immediate increase in count frequency, and survey effort was expanded to include all summer chum salmon streams. Between 1974 and 1980, survey effort in Hood Canal and Strait of Juan de Fuca streams averaged 65 miles per year. Technical staff of USFWS and treaty tribes began to make counts, which also added to the total miles surveyed. In 1978, the methodology for estimating south Puget Sound, Hood Canal, and Strait of Juan de Fuca chum salmon escapements was changed to a spawner curve approach, which required that serial surveys be conducted on each stream at seven to ten day intervals throughout the spawning season (Ames 1984). Survey effort scaled up in 1981 to support this new escapement approach, and between 1981 and 1997 survey effort averaged 107 miles per year for Hood Canal and Strait of Juan de Fuca summer chum salmon.

Concurrent with the 1978 change in the Puget Sound chum salmon escapement methodology, it was decided to recalculate chum escapements back to the 1968 return year using the spawner curve method. This decision was made based on a substantial increase in total Puget Sound chum salmon spawner survey effort in 1968. That year, over 3,800 fall chum salmon were tagged in the waters of Admiralty Inlet between October 7 and November 25 (Fiscus 1968). Because of tag recovery efforts in south Puget Sound and Hood Canal streams, the total Puget Sound chum salmon survey effort jumped from a pre-1968 average of about 90 miles per year to 437 miles in 1968 (Egan 1978). After 1968, survey effort stayed at a higher level, averaging 219 miles per year between 1969 and 1973, and then increased to over 1,000 miles per year after the 1974 Boldt Decision.

The decision to extend the total Puget Sound chum escapement data base back to 1968 is based on the improved survey data for fall chum stocks for the years following the tagging study. However, as discussed earlier, the increase in Hood Canal and the Strait of Juan de Fuca summer chum salmon index mileage did not occur until 1974. For the six year period of 1968 to 1973, summer chum escapement estimates are often based on limited data and resultant estimates are subject to question. This topic is discussed in more detail in Appendix Report 1.1.

1.4.2.2 Current Estimates

Since the summer chum salmon escapement estimates are an integral element of the recovery process, all spawner counts have been reexamined by the co-managers as a part of the development of this plan and updated estimates of escapements have been generated. The primary objectives for reevaluating the escapement numbers are; 1) to be sure that all available count data were included in the analysis, and 2) to ensure that the escapement estimates were made in a consistent manner for all years and all streams.

Spawning escapement estimates are annually derived by WDFW for all of the currently recognized, non-extirpated summer chum populations in Hood Canal and the Strait of Juan de Fuca (Table 1.1). WDFW has attempted to derive quantitative point estimates of escapement for most Washington chum populations since approximately 1968. However, both the field data collection and data analysis methods have an "adaptive learning" characteristic to them that has resulted in the expectation that the newer escapement estimates are generally considered to be of higher precision and accuracy than many of the older ones, due to 1) improvements in the understanding of the location, number and timing of field surveys required, and 2) increased knowledge of the fish entry pattern characteristics allowing more appropriate and consistent data analysis to account for the inevitable gaps and defects in the field survey observations due to environmental and/or personnel problems. Because of this, all summer chum escapement estimates for Hood Canal and Strait summer chum from 1968 to 1996 have been recalculated, to produce a historical summary of escapements with generally higher precision and accuracy.

> ***"...all summer chum escapement estimates for Hood Canal and Strait summer chum from 1968 to 1996 have been recalculated, to produce a historical summary of escapements with generally higher precision and accuracy."***

Escapement estimates for most Puget Sound chum populations are based upon the collection and analysis of multiple live and dead fish counts made in each stream throughout the spawning season.

Table 1.1 Spawning survey index reaches for summer chum in Hood Canal and the eastern Strait of Juan de Fuca[1]

WRIA	Stream name	WRIA river miles	Comments
15.0389	Big Beef Cr.	0.0-1.7	Fixed rack passage - operated late summer to late fall.
15.0412	Anderson Cr.	0.0-1.0	
15.0420	Dewatto R.	0.3-1.8	
15.0446	Tahuya R.	0.0-2.6	
15.0495	Big Mission Cr.	0.0-1.6	Early fall run (peaks late Oct., early Nov.).
15.0503	Union R.	0.3-2.1	
16.0001	Skokomish R (mainstem and SF)	9.0-13.3	Summer chum data collected incidentally during chinook surveys.
16.0230	Lilliwaup R.	0.0-0.7	
16.0251	Hamma Hamma R.	0.3-1.8	
16.0253	John Cr.	0.0-1.6	
16.0351	Duckabush R.	0.0-2.3	
16.0442	Dosewallips R.	0.02.3	
17.0012	Big Quilcene R.	0.0-2.8	
17.0076	Little Quilcene R.	0.0-1.8	
17.0219	Snow Cr.	0.0-1.5	
17.0245	Salmon Cr.	0.0-0.8	Includes rack counts.
17.0285	Jimmycomelately Cr.	0.0-1.5	
18.0018	Dungeness R.	0.0-18.9	Pink and chinook surveys.
18 0048	Greywolf R.	0.0-5.1	

[1] Surveys conducted late August to late October. On all streams except the Strait of Juan de Fuca tributaries directed chum survey effort is continued into the fall chum run period.

An estimate of the total abundance of chums in each stream from this data is made by use of an "area-under-the-curve" (AUC) methodology (Ames 1984). The AUC escapement methodology is based upon the principle that each species of salmon has an average stream residence life that can be used to convert a series of instantaneous estimates of live fish, collected through the spawning season, into an estimate of total spawning escapement for the surveyed stream. Other methods, such as rack and redd counts are also used where available and/or appropriate. Table 1.2 presents updated total escapement estimates, and Appendix Report 1.1 and Haymes (2000) contain detailed discussions of the procedures used in reassessing summer chum escapements.

Table 1.2. Total escapements for Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks (1974-1998).

Return year	Hood Canal escapement	St. Juan de Fuca escapement	HC/SJF combined
1974	12,281	1,768	14,049
1975	18,248	1,430	19,678
1976	27,715	1,494	29,209
1977	10,711	1,644	12,355
1978	19,710	3,080	22,789
1979	6,554	761	7,315
1980	3,777	5,109	8,886
1981	2,374	884	3,258
1982	2,623	2,751	5,374
1983	863	1,139	2,002
1984	1,414	1,579	2,993
1985	1,109	232	1,341
1986	2,552	1,087	3,639
1987	757	1,991	2,748
1988	2,967	3,690	6,657
1989	598	388	986
1990	429	341	770
1991	745	309	1,054
1992	2,368	1,070	3,438
1993	751	573	1,324
1994	2,423	178	2,601
1995	9,462	839	10,301
1996	20,514	1,084	21,598
1997	8,971	962	9,933
1998	4,020	1,270	5,290

1.4.2.3 Escapement Timing

Table 1.3 presents estimates of the average time periods when 10%, 50%, and 90% of the escapement for each summer chum salmon stock are achieved. These average values are derived from selected spawning ground survey data for the 1974 to 1998 period. Two different methodologies have been used to estimate spawner timing (both are presented in Table 1.3), and show similar results. There can be significant annual variations from the average timing of spawning for individual populations, where spawning timing can be substantially earlier or later than average.

Such annual differences in spawning timing may be influenced by environmental factors (e.g., water temperature, flow regime), and/or harvest impacts. A more detailed description of the data used, derivation methods, and results of the analysis is presented in Appendix Report 1.2.

Table 1.3. Summary of summer chum salmon average escapement timing estimates (10%, 50%, and 90% completion) derived with two different methodologies. See Appendix Report 1.2 for a detailed discussion of the methodologies used.

		PNPTC timing estimate				**WDFW timing estimate**			
Management Unit	Stock	No. Yrs (N)	10% date	50% date	90% date	No. Yrs (N)	10% date	50% date	90% date
Sequim Bay	Jimmycomelately	14	9/17	9/26	10/9	15	9/14	9/24	10/10
Discovery Bay	Snow/Salmon	20	9/19	9/29	10/13	20	9/18	9/29	10/16
Mainstem Hood Canal	Dosewallips	16	9/13	9/25	10/9	13	9/12	9/23	10/9
	Duckabush	24	9/19	9/28	10/11	16	9/17	9/29	10/11
	Hamma Hamma	23	9/17	9/27	10/8	21	9/14	9/27	10/10
	Lilliwaup	18	9/15	9/28	10/10	13	9/17	9/28	10/10
Quilcene Bay	Big/Little Quilcene	16	9/12	9/22	10/1	17	9/10	9/22	10/5
SE Hood Canal	Union	18	9/6	9/16	9/29	16	9/3	9/15	9/30

1.4.3 Harvest Data

The changing nature of the harvest of summer chum salmon during the last three decades created consistency problems with catch data. Prior to the 1974 Boldt Decision, Hood Canal, Sequim Bay, and the southern half of Discovery Bay were designated as salmon preserves, in which no commercial fishing was allowed (WDF et al. 1974). The Puget Sound salmon preserve system was established between 1921 and 1934. The harvest of summer chum outside of these salmon preserves was affected by the passage of Initiative 77 in 1934, which closed portions of the eastern Strait of Juan de Fuca and all of inner Puget Sound to fishing with purse seines prior to October 5th, and traps, set nets, and fish wheels throughout the year. The purse seine prohibition was amended in 1949 by the State Legislature to allow fishing on odd-numbered years for pink salmon from August 1 through September 1 in the eastern Strait and northern portion of Admiralty Inlet. Gill net fisheries during this period operated throughout Puget Sound waters, outside of the salmon preserves (WDF et al. 1974).

The purse seine regulations prior to 1974 provided some protection to summer chum salmon on non-pink years; with October 5th openings most summer chum presumably passed into terminal area salmon preserves. On the odd-numbered pink salmon years, all Puget Sound summer chum stocks likely were subjected to harvest by purse seines during the months of August and September. Gillnet fisheries did not have variable seasons and areas, and likely had a more uniform harvest impact on summer chum salmon stocks.

The 1974 Boldt Decision resulted in a number of changes in the conduct of net fisheries, including the elimination of most salmon preserves, the movement of fisheries to more terminal areas, and the splitting of harvest management areas into smaller, more discrete management units. This allowed a finer resolution of the contribution of various stocks to each area's harvest. For example, since a higher proportion of the harvest of Hood Canal summer chum salmon occurring in U. S. waters now takes place within the Canal, those catches can be allocated to Hood Canal stocks without the fear of a serious mis-allocation of south Puget Sound-origin fish to Hood Canal stocks. When major summer chum harvests occurred in northern Admiralty Inlet, there was significant uncertainty about the origin of the fish harvested. Due to more consistent fishing patterns and increased efforts to collect harvest data since 1974, summer chum salmon harvest estimates are now more representative of local stocks.

There were also some harvests of summer chum salmon in freshwater areas. There were recreational fisheries in selected streams throughout this period, and in some cases, freshwater Treaty Indian fisheries also occurred. In both cases, no reliable records were kept, however, the harvests in freshwater areas were of limited magnitude.

1.4.4 Run Size

1.4.4.1 Run Re-construction

To determine the total numbers of salmon returning to specific production areas, fish that are harvested in mixed stock and terminal fisheries must be allocated to the streams from which they originated. This allocation is done through a post-season process called "run re-construction", which splits the harvests in each catch area into the numbers of fish that likely are contributed by the individual stocks or management units thought to be transiting the area. A management unit is a stock or group of stocks which are aggregated for the purpose of achieving a desired spawning escapement objective. All estimated harvests for each stock or management unit are added to the escapement for that grouping to derive the estimated total return for each year.

Run Re-construction

A post season accounting of all salmon harvest and escapement for each individual stock or management unit.

The former Puget Sound salmon run re-construction models attempt to allocate salmon harvests by run or stock, and require many assumptions on migration routes and timing. When two salmon runs overlap in timing in a mixed stock harvest area, an allocation date splitting the two runs is selected even though it is known that some fish would be mis-allocated. When there are great differences in abundance levels between two runs, the harvest and run size of the smaller run could potentially be substantially overestimated. In the case of Hood Canal, as the summer chum salmon returns have declined, the hatchery fall chum salmon program have increased, creating the potential for significant mis-allocation of fall fish to the summer chum run size estimates. Mis-allocation of this type would potentially be the most serious at the end of the summer chum salmon harvest allocation period (July 1 to October 11), when the earliest portion of the fall chum return may be beginning to contribute to catches. The result of this type of mis-allocation is that the proportional impacting activities are greatest when summer chum salmon populations are lowest. Attempts have been made to use the traditional run reconstruction estimates to calculate recruit per spawner rates for individual streams (Johnson et al. 1997), which can compound the error because the mis-allocated fish are included with some extremely small numbers of wild fish.

1.4.4.2 New Summer Chum Run Re-construction

As discussed above, the mis-allocation of early returning fish from the abundant fall chum runs in Hood Canal had potentially inflated the estimates of summer chum salmon run sizes. For this restoration planning effort, a different version of run-reconstruction was developed to try to remove most of the fall chum salmon catch from summer chum run sizes. Within Hood Canal, this was accomplished by using earlier cut-off dates for catches to be allocated to summer chum stocks: Areas 9A and 12 - September 27, Area 12A - October 5, and Areas 12B, 12C, 12D - September 30.

While this approach presumably reduces the mis-allocation of fall chum salmon, it also possibly omits the catches of later returning summer chum from the run-reconstruction. Because of this, the potential for small under- or over-estimation biases for summer chum salmon run sizes may still exist. Another feature of the current run-reconstruction is the inclusion of Washington recreational and Canadian Area 20 commercial catches, which provides a more complete view of total harvest impacts. Table 1.4 presents the run size estimates resulting from the new run-reconstruction, and a more detailed discussion and tables are provided in Appendix Report 1.3.

Table 1.4. Total runsizes for Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks (1974-1998).

Return year	Hood Canal runsize	St. Juan De Fuca runsize	HC/SJF combined
1974	14,222	1,985	16,207
1975	29,112	1,728	30,840
1976	74,218	1,673	75,891
1977	16,679	1,810	18,488
1978	25,336	3,240	28,576
1979	9,513	900	10,413
1980	13,018	5,574	18,592
1981	5,857	1,140	6,997
1982	8,302	3,543	11,845
1983	3,500	1,218	4,718
1984	3,365	1,708	5,073
1985	4,411	412	4,822
1986	7,832	1,217	9,049
1987	3,965	2,181	6,147
1988	5,696	4,128	9,825
1989	4,472	795	5,267
1990	1,556	529	2,085
1991	2,195	425	2,620
1992	3,375	1,394	4,769
1993	866	644	1,509
1994	2,951	214	3,165
1995	9,977	882	10,858
1996	21,097	1,106	22,202
1997	9,372	985	10,357
1998	4,162	1,303	5,466

1.4.5 Age Data

Summer chum salmon in the region mature and return to their spawning streams primarily as 3- and 4-year old fish, plus relatively minor numbers of 5-year fish. To calculate survival rates for chum salmon, the number of recruits (returning fish) that are produced by each year's spawning population must be determined. To accomplish this, it is necessary to measure the age composition for each year's return; to ascertain how many fish returned from the three parent years that make up each return (e.g. the 1998 returns will be made up of 3-, 4-, and 5-year old fish from spawning in 1993, 1994, and 1995). The numbers of fish in each age category are assigned to their parent spawning escapement, and the total brood return for each spawning year is determined.

Aging of returning chum salmon is typically accomplished by analyzing scales or otoliths collected from fish caught in fisheries operating specifically on the stocks to be aged. Hood Canal and the Strait of Juan de Fuca summer chum stocks have not historically been subjected to directed fisheries, which has limited access to harvested fish for sampling purposes. The majority of summer chum salmon scale samples collected in the past 20 years have come from fish caught during fisheries conducted for other salmon species, primarily coho salmon. Since these fisheries are dependent on the abundance, location, and timing of different species of salmon, opportunities to sample summer chum salmon are often sporadic and not representative of all populations. A complicating factor is that prior to the Boldt Decision of 1974, Hood Canal was a commercial fishing preserve and marine area net fisheries did not occur in this region for any salmon. The only summer chum salmon age data available prior to 1976 are from sampling at the UW Big Beef Creek weir, and those data are useful only for that specific population (now extirpated). The low numbers of returning fish, coupled in recent years with protective harvest regulations, has minimized the numbers of summer chum salmon caught in local fisheries, which has virtually eliminated the opportunity to sample scales in mixed stock fisheries at acceptable levels for age determinations. Age data are now being collected for fish returning to the National Fish Hatchery on the Big Quilcene River (see Appendix Table 1.2) and to the Salmon Creek weir, and some sporadic age data have been collected from spawners in various streams during stock identification sampling.

The available age data for the combined Hood Canal summer chum returns are summarized in Appendix Table 1.3. Only ten of 29 data base years (1968-1996) had sample sizes of greater than 100 fish (77-82, 85-87, and 92), and only six years had sample sizes in excess of 200 fish. No long term age data base exists for Strait of Juan de Fuca stocks because there have been no fishery sampling opportunities owing to the lack of directed fisheries on these fish. In recent years, age samples have been collected from a supplemented summer chum population in Discovery Bay (Salmon Creek). The incomplete nature of the available age data prohibits the development of meaningful total brood return information for Hood Canal or the Strait of Juan de Fuca summer chum salmon; either as individual or combined populations. The lack of useful brood data further translates into a lack of estimates of survival, e.g. recruit per spawner rates.

The available summer chum age data can provide a general estimate of the average age at return for Hood Canal summer chum salmon. From 1977 to 1982 the Hood Canal sample sizes ranged from 102 to 1,201 fish per year (Appendix Table 1.3). These ages are representative only of the combined Hood Canal summer chum return, and constitute too short a period to construct meaningful estimates of brood returns. Average age composition for this six year period was 43.3% age-3, 54.6% age-4, and 2.1% age-5 fish. Based on these age compositions, the average age at return for Hood Canal summer chum salmon would be 3.59 years. Four other years, 1985-1987 and 1992, had more than 100 fish sampled, which provide limited measures of return year age compositions. The average return age of 3.6 years for Hood Canal summer chum salmon is used for risk assessments in this recovery plan.

1.4.6 Use of Stock Assessment Data

The quality and quantity of the available stock assessment data for summer chum salmon varies for individual parameters. New data will be incorporated into this recovery plan as it becomes available. The following are summaries of the utility of the various types of summer chum stock assessment data.

1.4.6.1 Escapement and Runsize

Both escapement and runsize (run re-construction) databases have been reviewed and substantially improved to provide the best available information for use in recovery planning. The summer chum salmon recovery plan focuses on escapement and runsize information for the 1974 through 1998 return years. While these estimates can be improved through the collection of additional data, the summer chum escapement and runsize numbers over this range of years are thought to be of sufficient reliability to meet most of the needs of the recovery plan. The disqualification of the 1968 through 1973 years is based on the limited utility of both escapement and harvest data for those years as discussed above. These early years should not be totally discounted, however, because various spawner counts may provide a sense of the prior magnitude of summer chum salmon escapements in some streams (see Appendix Report 1.1).

1.4.6.2 Age Data and Productivity Estimates

Because of the multi-brood life history pattern of summer chum salmon, any direct measures of their productivity necessarily depends on the availability of reliable age data. The age data that have been previously collected are not of sufficient quality to meet this need. A point that must be emphasized is that because of the lack of useable age data, no estimates of summer chum productivity (brood return or survival rates) are used in this recovery plan. The collection of appropriate age data for deriving survival rates is a high priority of this plan and is imperative to measure progress toward recovery. The limited extant age data are considered only in a general manner in the recovery plan.

> ***"... because of the lack of useable age data, no estimates of summer chum productivity (brood return or survival rates) are used in this recovery plan."***

1.4.6.3 Population Structure and Genetics

Genetic stock identification data have been collected for all current summer chum salmon stocks except for Dungeness. As with all stock assessment data, the information from GSI analyses can be improved through the collection of additional genetic data. A significant short-coming is the lack of specific stock contribution information for various marine area fisheries, by time and location. There is also a lack of data relating to various biological traits, like age (discussed above), sex ratios, body size, etc.

1.5 Period of Decline

1.5.1 Introduction

The summer chum salmon populations of the Hood Canal and Strait of Juan de Fuca streams are affected by different environmental and harvest impacts, and display varying survival patterns and stock status trends. The summer chum stocks from both regions have dropped in abundance, but at different times and with different trends of abundance. While the rate and pattern of decline varies by individual population, all Hood Canal summer chum populations (except Union River) experienced a decline after 1978, and Strait of Juan de Fuca populations dropped in abundance ten years later.

1.5.2 Hood Canal

The escapement and overall abundance of summer chum salmon in Hood Canal have declined abruptly, beginning with the 1979 return year. In that year, the Hood Canal summer chum run dropped to a total return of 9,513 and an escapement of 6,554 spawners. Both of these numbers are substantially lower than the previous low values; 14,222 runsize in 1974 and 10,711 fish escaping in 1977 (see Tables 1.2 and 1.4). The 1979 return is made up predominately of 1976 brood age-3 fish (34.7%) and 1975 brood age-4 fish (61.1%)(see Appendix Table 1.3). This age composition falls within the expected range for summer chum salmon, and indicates that the low return in 1979 is not the result of a failure of just one of the two brood years. Parent year escapements are strong for the 1975 and 1976 broods (18,248 and 27,715 spawners respectively), and it seems probable that reduced survivals for both the 1975 and 1976 broods have contributed to the decline in the 1979 return.

The magnitude of the decline of Hood Canal summer chum can be demonstrated by examining average escapements and runsizes before and after the decline. Table 1.5 presents the five year average escapements and runsizes from 1974 through 1998. The average escapement of summer chum salmon for the 1979-1983 return years (3,238 spawners) represents a greater than five-fold drop from the average escapement of the previous five years (17,733 spawners). The decline continues through the 1980s and early 1990s, with five year average escapements dropping to a low of 978 spawners for the 1989-1993 period. The lowest single escapement was observed during this period, with only 429 spawners estimated in 1990 (Table 1.2). Runsizes for Hood Canal stocks display a similar, but somewhat less abrupt rate of decline (Table 1.5). The fact that runsize drops coincident to escapement is evidence that a reduction in the production (total survival) rate has been a significant contributor to the decline.

One of the 12 summer chum salmon streams in Hood Canal, the Union River, does not follow the declining trend. Union River summer chum escapements are low prior to 1980, but then increase substantially and have apparently stabilized at escapement levels that are approximately 3 to 4 times pre-1979 levels (see Appendix Table 1.1).

Table 1.5. Five year average runsizes and escapements for Hood Canal summer chum stocks, 1974 to 1998.

Return Years	Hood Canal runsize	Hood Canal escapement
1974-78	31,913	17,733
1979-83	8,038	3,238
1984-88	5,054	1,760
1989-93	2,493	978
1994-98	9,512	9,078

1.5.3 Strait of Juan de Fuca

The drop in summer chum salmon escapements and runsizes for the stocks in the eastern Strait of Juan de Fuca, occurred in 1989, a decade after the decline in Hood Canal. Escapements dropped three-fold, from a 1984 to 1988 average of 1,716 spawners (Table 1.6), to only 388 spawners in 1989. Escapements stabilized at this low level, averaging 536 spawners for the 1989 through 1993 period. The streams of this region also experienced low escapements in 1979 (761 spawners), but in contrast to Hood Canal, Strait of Juan de Fuca summer chum escapements immediately rebounded in 1980 (5,109 spawners), and continued to be strong until the drop in 1989 (Table 1.2). As with Hood Canal stocks, the runsizes of Strait of Juan de Fuca summer chum stocks declined for the same return years as escapements (Table 1.6), indicating that an overall drop in total production was a major contributor to the observed decline.

Table 1.6. Five year average runsizes and escapements for Strait of Juan de Fuca summer chum stocks, 1974 to 1998.

Return years	Strait of Juan de Fuca runsizes	Strait of Juan de Fuca escapements
1974-78	2,087	1,883
1979-83	2,475	2,129
1984-88	1,929	1,716
1989-93	757	536
1994-98	898	867

1.6 Recent Abundance Trends

The abundance of the Hood Canal summer chum salmon has shown improvement for the 1995 through 1998 return years, and Strait of Juan de Fuca summer chum have experienced more modest increases during the same years (Table 1.2). In recognition of the critical status of Hood Canal summer chum, actions to protect returning spawners in terminal area fisheries were initiated in 1992, and continued through the present year. Supplementation programs on the Big Quilcene River, Lilliwaup River and Salmon Creek were begun in 1992, with the goal of rebuilding depressed summer chum stocks in those drainages. Projects were also begun in 1996 to reintroduce summer chum into Chimacum and Big Beef creeks where they had been extirpated. These actions are addressed in more detail in section 3.2 Artificial Production.

Affected at least in part by the above actions and programs, average total run size of Hood Canal summer chum in the most recent five years (1994-1998) is substantially higher than observed over the previous 14 years (Table 1.4), and the total escapements of Hood Canal summer chum during the most recent four years (1995 - 1998) are substantially higher than annual totals observed for the previous 14 years (Table 1.2). Hood Canal summer chum escapements have averaged 9,078 spawners over the last five years (2,423 - 20,514 range), which represents a substantial increase over the average escapement for the preceeding five years (Table 1.5). Escapements to Strait of Juan de Fuca streams have averaged 867 spawners for 1994 through 1998, a 62% increase over the 536 fish post-decline average (1989-1993) (Table 1.6). While the improvements in total run size and escapements for these summer chum stocks are encouraging, the time frame is short, and some individual populations are still experiencing very small escapements.

The estimated natural spawning summer chum escapement in 1995 was 10,301 (9,462 in Hood Canal tributaries and 839 in the Strait of Juan de Fuca tributaries). The 1995 escapement to the Big Quilcene was the highest observed in the 24 year database record to date (4,520 fish). Improved escapements over recent years were also noted on most of the streams entering the west side of Hood Canal, with 476 in the Hamma Hamma River, 825 in the Duckabush River, and 2,787 in the Dosewallips River. There were poor returns to the Lilliwaup River and Little Quilcene River (79 and 54 fish respectively). No fish were observed in the streams entering the east side of Hood Canal (Big Beef Creek, Dewatto River, Anderson Creek, and Tahuya River). The Union River had a good escapement of 721 fish. In the Strait of Juan De Fuca, Salmon Creek and Jimmycomelately Creek experienced fairly good escapements (591 and 223 fish respectively), but the Snow Creek escapement was again extremely poor (25 fish), continuing a trend.

The estimated natural spawning summer chum escapement in 1996 was 21,598 fish (20,514 in Hood Canal tributaries and 1,084 in the Strait of Juan de Fuca tributaries). The overall upward trend in escapement from recent years was primarily carried by the major streams entering the west side of Hood Canal. A new record chum escapement was observed in the Big Quilcene River (9,250 fish). However, this return originated from a mix of natural and hatchery produced fish, and it is assumed a significant portion of the spawners were progeny of the artificial production program. The Dosewallips River also had a record escapement of 6,976 chum, all of wild origin. The Hamma Hamma and Duckabush River had good returns also (774 and 2,650 fish respectively). On a down note, in this region Lilliwaup Creek had another poor escapement of 100 fish and the eastern Hood

Canal streams again showed no evidence of any significant returns. The Union River escapement was fair (494 fish). In the Strait of Juan De Fuca, Salmon Creek experienced a fairly good escapement of 785 fish (progeny of natural spawning and an on-going enhancement program), but Snow Creek and Jimmycomelately escapements were poor(160 and 30 fish respectively).

The estimated natural spawning summer chum escapement in 1997 was 9,933 fish (8,971 in Hood Canal tributaries and 962 in the Strait of Juan de Fuca tributaries), a declining trend from the previous two relatively strong years. Again, the majority of escapement occurred in the major streams entering the west side of Hood Canal. The Big Quilcene River again experienced a good spawning run (7,339 fish). As in 1996, this return originated from a mix of natural and enhancement program produced fish, and it is assumed a significant portion of the spawners were progeny of the artificial enhancement program. The Hamma Hamma, Dosewallips and Duckabush rivers had radical declines in spawner abundance from the previous two years (104, 47, and 475 fish respectively). Lilliwaup Creek and the Little Quilcene continued to be weak, with 26 and 29 natural spawners estimated respectively. The eastern Hood Canal streams again showed no evidence of any significant returns. Six fish were observed in the Dewatto, however. The Union River escapement was again fair (410 fish). In the Strait of Juan De Fuca, Salmon Creek experienced a fairly good escapement of 834 fish (progeny of natural spawning and an on-going enhancement program), but Snow Creek and Jimmycomelately escapements were again poor (67 and 61 fish respectively).

The estimated natural spawning summer chum escapement in 1998 was 5,290 fish (4,020 in Hood Canal tributaries and 1,270 in the Strait of Juan de Fuca tributaries), continuing a declining trend from the strong years in 1995 and 96. Again, the majority of escapement occurred in the major streams entering the west side of Hood Canal. The Big Quilcene River again experienced a good natural spawning run (2,244 fish). As in 1996 and 97, this return originated from a mix of natural and enhancement program produced fish, and it is assumed a significant portion of the spawners were progeny of the artificial enhancement program. The Hamma Hamma, Dosewallips and, Duckabush rivers had poor to fair spawner abundance (143, 336 and 226 fish respectively). Lilliwaup Creek continued to be weak, with 24 fish. The Little Quilcene River re-bounded a little, with a 265 fish escapement. The eastern Hood Canal streams again showed no evidence of any significant returns. However, twelve fish were observed in the Dewatto. The Union River's escapement was again fair, but down from last year (223 fish). In the Strait of Juan de Fuca, Salmon Creek experienced a good escapement of 1,144 fish (progeny of natural spawning and an on-going enhancement program), but the Snow Creek and Jimmycomelately 1998 escapements were again poor (28 and 98 fish respectively).

The 1989-93 period represents the years of lowest escapements, an average of only 1,514 total summer chum escaping to the region (Tables 1.5 and 1.6). By comparing the mean escapement of that five year period to the most recent five year mean escapement, a substantial improvement in escapements is apparent; increases of 928% in Hood Canal, 162% in the Strait of Juan de Fuca, and up 657% for the region as a whole. The results in Hood Canal have been enhanced by the strong returns to the supplementation program at Big Quilcene. However, if the Quilcene fish are removed from recent average escapements, the remaining Hood Canal streams averaged 793 spawners for 1989-93 and 3,416 spawners for 1994-98, a 431% increase. The improved escapements to wild production streams combined with the success of supplementation on selected streams has substantially lowered the extinction risk for this region. For descriptions of the recent performances of individual stocks, see the following stock evaluations.

1.7 Stock Evaluations

1.7.1 Introduction

The evaluation tools that will be used to identify summer chum stocks performing poorly and to measure the success of recovery measures are a major component of this recovery plan. Three approaches used to evaluate summer chum stocks are described in the following sections: 1.7.2 - Stock Definition and Status (SASSI), 1.7.3 - Annual Abundance Evaluation, and 1.7.4 - Stock Extinction Risk. These are independent assessment, each serving a separate purpose.

The first stock evaluation approach reviews and updates the summer chum stock definitions and status ratings originally reported in the 1992 Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993). This inventory, also known as SASSI, presents criteria for identifying stocks based on their degree of reproductive isolation, and rates the status of each stock into the general categories of healthy, depressed, critical, extinct, and unknown. For this recovery plan, the most recent information on historical and current summer chum salmon distribution and on the genetic profiles of the populations has been reviewed. This analysis has resulted in an updated list of 16 summer chum stocks, which form the basic population units used throughout this recovery plan. Status ratings for each stock are also presented, primarily for use in various other processes and evaluations that are based on the SASSI approach. This recovery plan does not directly use these SASSI status ratings, but instead relies on the more detailed status evaluations below; which specifically focus on annual escapement numbers and extinction risk for summer chum salmon.

"This analysis has resulted in an updated list of 16 summer chum stocks, which form the basic population units used throughout this recovery plan."

The second evaluation approach compares spawner escapements to stock-specific critical abundance thresholds. This annual process reviews escapements, and identifies (flags) any stock that falls below its threshold. At the end of each season, all flagged stocks will undergo an in-depth review of stock performance, and possible causes of the low escapement will be identified. If necessary, remedial measures will be incorporated into recovery activities the following year.

The third procedure is used to estimate extinction risk based on the numbers of effective spawners representing each summer chum stock. This evaluation assesses extinction risk using an approach described in the paper Prioritizing Pacific Salmon Stocks for Conservation, by Allendorf et al. (1997). The approach focuses on the minimum numbers of spawners required to have a viable population, and estimates the risk of extinction for populations below the viability threshold. Other sources of risk are acknowledged (e.g. habitat loss and climate change), but no attempt has been made to incorporate these additional risks. While it is clear that salmonids are affected by an extensive range of risk factors, we do not have the data or the knowledge to conduct complete risk assessments for any of our summer chum populations. That does not mean, however, that we should not attempt to estimate risk, and minimum population size criteria (as recommended by Allendorf et al.) can serve to guide the conservation of summer chum stocks while the science of risk assessment develops.

1.7.2 Stock Definition and Status (SASSI)

The status of summer chum stocks in the Hood Canal region has been reevaluated as part of the development of this comprehensive recovery plan for the summer chum. The evaluation generally follows protocols established by the WDFW and Treaty Tribes in preparing the 1992 Salmon and Steelhead Stock Inventory (SASSI) (WDF et al. 1993). Newly available information has been reviewed in making the evaluation. Results of the evaluation include:

- A revised description of the summer chum stocks. Revisions are based on review of existing and new stock assessment data (including genetic stock identification data, and adult escapement and catch data). The description includes existing stocks, documents recent extinctions, and identifies possible former summer chum distributions based on limited available evidence.

- A revised description of the status of the stocks following the descriptive protocol of SASSI (e.g., healthy, depressed, critical or unknown status).

The SASSI process inventories naturally reproducing stocks of salmon and steelhead regardless of origin (including native, non-native, and mixed parentage). It is a two stage approach which first identifies individual stocks, and then determines their current status. The factors contributing to the current status of summer chum stocks are discussed in detail in Parts Two and Three.

SASSI Stock Definition

The fish spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.

The primary criterion used to distinguish stocks is that there is evidence of substantial reproductive isolation, either temporally or spatially, that over time leads to local adaptation of individual stocks. While run timing and spawning distributions are the most common stock determinants, documented genetic differentiation is also evidence of reproductive isolation, and is also used to identify stocks.

In this stock assessment, the current status of each of the identified stocks has been rated primarily based on trends in survival rates or population size, but the process does not focus directly on possible future risks to the stocks or causative factors. Stocks with escapement, run-size, and survival levels within normal ranges given available habitat, and not displaying a pattern of chronically low abundance, are rated as healthy stocks. Those stocks that currently display low production or survival values are assigned to one of two separate rating categories: depressed stocks or critical stocks, depending on the current condition of the stock. Stocks are also rated as unknown stocks when data limitations do not allow assessments of current status.

SASSI Status Definitions

Healthy Stock: ***A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.***
Depressed Stock: ***A stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.***
Critical Stock: ***A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.***
Unknown Stock: ***There is insufficient information to rate stock status.***
Extinct Stock: ***A stock of fish that is no longer present in its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.***

The rating category for stocks in the extinct category is for stocks whose recent extinctions are documented in current stock assessment data bases. Past extinctions are not included because SASSI is a current resource inventory and the historic information on lost stocks is incomplete and often anecdotal. A more detailed discussion of the SASSI definitions is provided in the Appendix Report 1.4.

The following are individual stock discussions that review the stock definitions and status ratings for existing stocks, recently extinct stocks, and possible historic distributions of summer chum salmon in Hood Canal and the Strait of Juan de Fuca streams.

1.7.2.1 Existing Stocks

The 1993 salmon and steelhead inventory identified two summer chum salmon stocks in the streams of the eastern Strait of Juan de Fuca; a stock in Discovery Bay, and another stock in Sequim Bay. In Hood Canal, Union River was designated as a separate stock, and the summer chum salmon spawning in all other streams were designated as a single stock because of a lack of genetic data for individual spawning groups. At the time it was recognized that there may be more summer chum stocks in the region: "Preliminary results from ongoing genetic studies indicate that there may be more than two summer stocks in Hood Canal" (WDFW and WWTIT 1994). The following stock status ratings were assigned in the 1993 inventory to the four stocks: Hood Canal, critical; Union River, healthy; Discovery Bay, critical; and Sequim Bay, depressed.

Existing stocks are those stocks for which there is good information that they continue to exist and are likely to be sustainable. Spawner count data for each stream that currently supports summer chum salmon spawning have been reexamined for evidence of temporal or spacial overlap of spawning populations. There is strong temporal separation between summer and fall chum stocks in the region, with the exception of Big and Little Mission creeks which are an early fall stock (see discussion below). Because of the geographic separation of the majority of summer chum spawning streams, substantial spacial overlap of spawners is judged to be unlikely, except in Snow and Salmon creeks (Discovery Bay) and in Big and Little Quilcene creeks. Genetic differentiation has been examined for ten spawning populations using the results of a new Genetic Stock Identification (GSI) study. Most spawning populations have been found to display significant genetic differentiation (Table 1.7, see also Appendix Figures 1.1 and 1.2).

Genetic Stock Identification (GSI)

A method that can be used to characterize populations of organisms based on the genetic profiles of individuals. The GSI process consists of a series of steps: 1) collect selected tissues from a representative sample of individuals from the population(s) under investigation; 2) develop genetic profiles for the individuals in each population by conducting starch-gel electrophoresis and histo-chemical staining using tissue extracts; 3) characterize each population by aggregating the individual genetic profiles and computing allele frequency distributions; and 4) conduct statistical tests using the allele counts characterizing each population to identify significantly different populations.

Based on the standard of substantial reproductive isolation (indicated by distributional and genetic differences), nine existing summer chum stocks have been identified, three in Strait of Juan de Fuca streams and six in Hood Canal streams (Table 1.8). Details regarding the categories and status of the individual summer chum stocks are discussed below.

Union River

Stock Definition - The Union River enters Lynch Cove at the far end of the hook in south Hood Canal and is relatively far removed from the other known populations of summer chum. Results of genetic analysis show the Union River population is significantly different from the other populations. Also, the summer chum of Union River show earlier run timing, measured by appearance in spawner surveys, than summer chum of other streams in the region. For all these reasons, the Union River is categorized as a separate native summer chum stock

Stock Status - The records show annual escapement estimates of 100 or less spawners during the 1970s (Appendix Table 1.1). Since that time, the estimates have been considerably higher most years, with the highest estimate being almost 1,900 spawners in 1986. The Union River is the only non-supplemented summer chum population that has increased since the 1970s.

Origin and Type - A **native** stock with **wild** production.
Status - Healthy.

Table 1.7. Results of log-likelihood G-tests (Sokal and Rohlf, 1981) between Hood Canal and Strait of Juan de Fuca summer chum salmon populations using only loci that were variable in at least one of the two collections in each comparison. N = sample size, NS = not significant ($P > 0.05$), * = $0.05 > P > 0.01$, ** = $0.01 > P > 0.001$, *** = $P < 0.001$.

		Population								
Population (years sampled)	N	1	2	3	4	5	6	7	8	9
1) Snow Cr. ('86)	50									
2) Salmon Cr. ('86,'97)	150	NS								
3) Jimmycomelately Cr. ('86)	100	**	***							
4) Duckabush R. ('85,'86,'92)	124	***	***	***						
5) Quilcene Bay/NFH ('97)	58	***	***	***	*					
6) Hamma Hamma R. ('85,'86,'94,'95,'97)	101	***	***	***	NS	**				
7) Quilcene Bay & R. ('92,'93,'94)	262	***	***	***	***	**	NS			
8) Union R. ('85,'86,'92,'93,'97)	152	***	***	***	***	***	***	***		
9) Lilliwaup Cr. ('85,'86,'92,'93,'97)	268	***	***	***	***	***	***	***	***	
10) Dosewallips R. ('86,'92)	102	**	***	***	***	***	***	***	***	***

Lilliwaup Creek

Stock Definition - The native summer chum of Lilliwaup Creek are shown to be significantly different from other summer chum populations in Hood Canal based on analysis of genetic samples (Table 1.7). This genetic data and the geographic separation from the other populations lead to Lilliwaup being categorized as a separate stock.

Stock Status - Prior to 1979, estimated annual escapements have ranged from several hundred to over one thousand spawners. Since that time no single year's estimated escapement has exceeded 300 spawners and for the majority of years has been less than 100 spawners. The short-term severe decline after 1978, followed by chronically low escapements since, indicates the stock status is critical.

Origin and Type - A **native** stock with **wild** production.
Status - Critical based on chronically low escapements.

Hamma Hamma

Stock Definition - Genetic analysis shows samples from native summer chum of the Hamma Hamma River to be significantly different from samples of other Hood Canal areas, except for Quilcene Bay/River (Table 1.7). The relatively large geographic distance between the Hamma Hamma River and Quilcene Bay (with both the Dosewallips and Duckabush rivers located in between) argues against the possibility of the Hamma Hamma and the Quilcene Bay populations being a single stock.

Stock Status - Before 1980, the Hamma Hamma River has had annual escapements in the 1,000s (Appendix Table 1.1). Beginning in 1980, the numbers have declined to the 100s per year. During the 1990s, the annual numbers of estimated spawners have fluctuated from below 100 to several hundred. The most recent 5 years of escapements have averaged less than 10% of the escapements of the 1970s, and this stock is considered to be depressed.

Origin and Type - A **native** stock with **wild** production.
Status - Depressed due to chronically low escapements.

Duckabush

Stock Definition - An examination of genetic information for the native Duckabush summer chum stock indicates it is significantly different from other Hood Canal summer chum populations except for the Hamma Hamma (Table 1.7). The finding of no significant difference does not necessarily mean these two populations are of the same stock. There may be significant differences not detectable at the loci examined. Genetic results tend to be more definitive in confirming differences between samples (e.g., the finding of a significant difference based on results showing 95% probability that the samples are not from the same randomly sampled population), as opposed to indicating they are from the same population. If no difference is indicated by these analyses, it is not necessarily appropriate to assume the tested groups are from the same population. It is only an indication that they might be from the same population. In these cases, other factors are also considered in making a determination of whether or not the two sampled groups are of the same stock. In the case of Duckabush, geographic distance between the Duckabush and the Hamma Hamma, and between the Duckabush and other summer chum populations, appears sufficient to categorize Duckabush as a separate stock. The geographic differences between the Duckabush and other summer chum streams appear sufficient when comparisons are made with geographic distances between other stocks identified as significantly different by genetic analysis (e.g., between the Dosewallips and the Big Quilcene/Little Quilcene stocks).

Stock Status - The record of escapement estimates (Appendix Table 1.1) shows the Duckabush falling from escapements in the thousands during the 1970s to less than one hundred spawners in the late 1980s. In the 1990s, the escapement estimates have increased into the low hundreds of spawners, but are still substantially less than what has been estimated for the 1970s.

Origin and Type - A **native** stock with **wild** production.
Status - **Depressed** due to chronically low escapements.

Dosewallips

Stock Definition - Analysis of genetic sampling data shows Dosewallips to be significantly different from other Hood Canal summer chum populations, including the two most proximal populations on the west side of Hood Canal; that is, Quilcene to the north and Duckabush to the south (Table 1.7). Dosewallips is categorized as a separate native stock for this reason and because of the geographic separation from these other populations..

Stock Status - Escapement estimates for Dosewallips (Appendix Table 1.1) have decreased in the 1980s to less than 100 spawners in some years and several hundred in other years. During the 1970s, most escapements are over 1,000 spawners, extending up to over 3,000. Escapements appear to be rebounding in the 1990s with the highest escapement on record of almost 7,000 spawners in 1996. However, the 1997 escapement is only 47 spawners, lower than expected given the apparent increasing trend. This one year's severely low escapement could be an aberration in the pattern of recovery. Resolution of what is happening with this stock should be forthcoming as escapements continue to be monitored.

Origin and Type - A **native** stock with **wild** production.
Status - **Depressed** due to chronically low escapements.

Big Quilcene/Little Quilcene

Stock Definition - The Big Quilcene and Little Quilcene rivers enter salt water close to each other at the extreme northern end of Quilcene Bay. No genetic analysis of the spawning population in the Little Quilcene River has been conducted. Only the bay and Big Quilcene River have been adequately sampled, and the bay genetic samples may have included native chum from Little Quilcene as well as Big Quilcene river - the only two summer chum streams in the bay. No assessment of potential genetic differences between populations of the two streams is possible with the current data. Because of the close proximity of the two streams and the likelihood of mixing of spawners, Big and Little Quilcene summer chum salmon are designated as a single native stock.

Stock Status - While estimated escapements initially drop beginning in 1979, an even more substantial drop occurs in both Big Quilcene and Little Quilcene rivers during the middle 1980s (Appendix Table 1.1). By the early 1990s, escapement estimates are in single digits in both streams. The numbers of spawners subsequently improve in the Big Quilcene River probably due at least in part to harvest management protection measures. The Big Quilcene River population substantially rebounds beginning in 1995 as a result of the supplementation project begun in 1992. The escapement levels remain extremely low from 1989 through 1994 in the Little Quilcene River, with a high annual estimate of 12 spawners and with estimates of one or no spawners in four of these years. More recently the escapement numbers in the Little Quilcene River have begun to rise, but are still low compared to the historical numbers.

The recent escapement numbers for this stock are high relative to documented historical numbers, but 1) because these high numbers likely are primarily the result of supplementation releases rather than natural production and 2) because the Little Quilcene River escapements are still low, and finally 3), because habitat conditions are poor and may constrain natural production in both rivers, the status of the stock is judged to be depressed.

Origin and Type - A **native** stock with **composite** production.
Status - **Depressed**.

Snow/Salmon

Stock Definition - Salmon and Snow creeks are located at the northern end of Discovery Bay on the Strait of Juan de Fuca. The mouths of the creeks are close to each other and at one time Snow Creek flowed into Salmon Creek before it entered the bay. The streams were separated by a man-made diversion early in the twentieth century. Results of genetic sampling (log-likelihood G-tests) from analysis of summer chum protein samples (Table 1.7), do not show a significant difference between Snow and Salmon creeks. The close proximity of the two streams, the absence of an indicated difference from the genetic sampling results, and the streams' geographic history support categorizing the Snow Creek and Salmon Creek populations as a single native stock.

Stock Status - The historical escapement record (Appendix Table 1.1) shows Salmon Creek to be fairly stable over the last nine years and within the approximate historical range. On the other hand, Snow creek escapements have dropped to extremely low levels in the late 1980s and early 1990s, with 33 or fewer spawners per year from 1989 through 1995. In each of the last two years (1996 and 1997), escapements of approximately 150 spawners have been estimated for Snow Creek, perhaps due at least in part to spawners returning from the Salmon Creek supplementation project (summer chum fry are released from net pens in the bay). The escapement data suggest that the stock is fairly stable, at least in Salmon Creek and may be beginning to recover in Snow Creek. However, the returns to Snow Creek are far below the historical escapement estimates (Appendix Table 1.1).

Origin and Type - A **native** stock with **composite** production.
Status - **Depressed** due to chronically low escapements.

Jimmycomelately

Stock Definition - Genetic analysis indicates that summer chum of Jimmycomelately Creek are significantly different from the Snow/Salmon summer chum stock (Table 1.7). Jimmycomelately Creek is located in a separate bay where no other summer chum populations are known to have existed. The geographic isolation and genetic results support categorizing Jimmycomelately as a separate native stock.

Stock Status - The record of escapement estimates (Appendix Table 1.1) shows Jimmycomelately to have escapements fluctuating from several hundred to 1,000 in the 1980s, with only one year below 100 total spawners. However, in the 1990s, the escapement numbers have generally dropped with three of the last five years (1994-1998) having escapement estimates of 61 or less.

Origin and Type - A **native** stock with **wild** production.
Status - Critical based a short term severe decline in escapements.

Dungeness

Stock Definition - Summer chum have been periodically observed during the months of September and October in the Dungeness River in the course of monitoring and collecting chinook and pink salmon data. No escapement estimates for Dungeness summer chum have been made but indications are that a modest sized, self-sustaining run is present in the system. The Dungeness River appears sufficiently separated geographically from the closest known population of summer chum (Jimmycomelately in Sequim Bay) to be categorized as a separate native stock. For a more detailed discussion of the evidence of summer chum salmon in the Dungeness River, see Appendix Report 1.1 and Plan Supplemental Report No. 1 (Haymes 2000).

Stock Status - Spawning ground survey effort in the Dungeness in September and October is focused on chinook and pink (odd-years only) salmon. Summer-timed chum salmon are consistently seen during surveys of the lower Dungeness River mainstem. The highest count representing summer chum salmon is 199 fish observed in the lower 3.2 miles of the river on September 22, 1976. Survey conditions are typically rated as poor to fair during these surveys and the emphasis on other species sometimes results in incomplete coverage of potential summer chum holding and spawning areas. Since 1987, however, summer-timed chum salmon have been observed in the Dungeness River every year, with partial peak counts ranging between 1 and 60 fish. The incomplete nature of the existing count data prohibits the development of total escapement estimates, however, the data do indicate the presence of a small self-sustaining stock of unknown status. A high priority should be placed on additional spawning ground surveys on the lower Dungeness River during the months of September and October to determine the status of summer chum salmon.

Origin and Type - A **native** stock with **wild** production.
Status - Unknown.

1.7.2.2 Recently Extinct Stocks

Known, recently extinct stocks are those stocks where there is strong evidence to show that a stock formerly existed but has now been extirpated from its former stream. Of the 16 stocks identified (Table 1.8), seven are recent extinctions. The determination that these were distinct stocks is based solely on past distribution and presumed past reproductive isolation. Four of the seven extinctions occurred in Kitsap Peninsula streams.

Big Beef

Stock Definition - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

Stock Status - The record (Appendix Table 1.1) shows Big Beef escapement estimates exceeding 1,000 spawners in 1975 and 1976, though in most years immediately before and after, the escapements appear far less and generally in the low hundreds. Summer chum all but disappear after 1981 and except for an estimated 22 spawners in 1984, zero spawners have been estimated in all years since.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Anderson

Stock Definition - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

Stock Status - Estimated escapements for Anderson Creek (Appendix Table 1.1) show a small population of just over 200 spawners occurring in the 1970s. That population does not appear to have been stable, with estimates of 0 and 16 spawners during 1974 and 1978 respectively. Estimated escapement drops to zero in the early 1980s and the stock has ceased to exist.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Dewatto

Stock Definition - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

Stock Status - Estimated escapements for the Dewatto River (Appendix Table 1.1) show a gradual reduction of spawners over time, from escapements of more than a thousand in the early 1970s, to hundreds in the later 1970s, to less than 100 in the 1980s, and finally, to zero or near zero in the 1990s.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Tahuya

Stock Definition - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

Stock Status - The record (Appendix Table 1.1) shows escapements of Tahuya River summer chum spawners have dropped from estimates ranging between the high hundreds and thousands during the 1970s, down to below two hundred during the 1980s. Beginning in the early 1990s, the estimates have been essentially zero.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Skokomish River

Stock Definition - No escapement estimates exist for the Skokomish River. Spawner surveys generally have not been specifically directed at native summer chum in this river system until recently. However, surveys for other species, notably chinook, would be expected to have reported any observations of summer chum and, in fact, reports of summer chum in late September and in early to mid October do exist in the historical spawner survey record. The tribal fishery catches recorded for the Skokomish River are within the expected time frame for the summer run (i.e., prior to October 15); however, in recent years the numbers have been very low. Currently, only small, occasional numbers of summer chum, and not a sustainable population, are believed to occur in the Skokomish River.

Stock Status - A number of factors have likely contributed to the demise of summer chum. Summer chum habitat has been severely degraded by human developments in the Skokomish River watershed. The summer chum population may also have been impacted by local commercial fisheries, though the fisheries have been primarily directed at other species. Even though documentation of summer chum occurrence in the Skokomish River is sparse, the size of the river, and likelihood that natural habitat conditions would have supported summer chum, leads to the conclusion that summer chum have been eradicated as a result of human activities. It appears reasonable that a population of summer chum in the Skokomish River would have been a separate stock, at least based on geographic separation from other stocks. The Skokomish is therefore judged to be a recently extinct stock.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Finch Creek

Stock Definition - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

Stock Status - The Hoodsport Salmon Hatchery began trapping chum salmon at Finch Creek in 1953. Rack counts show a bimodal chum run in the creek during the 1950s and 1960s, with the first peak occurring in early October. Since this timing is consistent with summer chum spawning, it is reasonable to conclude that Finch Creek supported a modest summer chum run. By 1970, this summer spawning stock had been extirpated in Finch Creek.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Chimacum

Stock Definition - Geographic distance from other stocks is the basis for identifying this recently extinct native population as a separate stock.

Stock Status - No escapement estimates exist for Chimacum Creek and few spawner surveys by WDFW or tribal staffs have occurred until recent years; however, several surveys that have been made during early October in the middle 1970s and early 1980s have reported small numbers of summer chum. Summer chum surveys also have been made in the 1970s as part of a local high school project sponsored by teacher Ray Lowrie. Summer chum counts of over 100 have been made in several years but there are no escapement estimates (Ray Lowrie, pers. comm.) The summer chum run disappeared by the middle 1980s. The run's demise is believed due to a combination of habitat degradation and poaching.

Origin and Type - A **native** stock with **wild** production.
Status - Extinct.

Table 1.8. Summary of Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks, including existing and recently extinct stocks and stock origin

Stock	Status	Origin
Big Beef	Extinct	Native
Anderson	Extinct	Native
Dewatto	Extinct	Native
Tahuya	Extinct	Native
Union	Healthy	Native
Skokomish	Extinct	Native
Finch	Extinct	Native
Lilliwaup	Critical	Native
Hamma Hamma	Depressed	Native
Duckabush	Depressed	Native
Dosewallips	Depressed	Native
Big/Little Quilcene	Depressed	Native
Chimacum	Extinct	Native
Snow/Salmon	Depressed	Native
Jimmycomelately	Critical	Native
Dungeness	Unknown	Native

1.7.2.3 Possible Additional Historic Distributions

A "possible historic distribution" category is used for groups of fish where there is some evidence of former summer chum occurrence in a stream but the evidence is insufficient to determine whether or not there was a distinct stock. A distinction is made here between stock and historic distribution, where a stock is defined under SASSI as being (or formerly has been) self-sustaining and reproductively isolated from other stocks based on available evidence.

The determinations of existing and extinct stocks have been made based upon relatively strong evidence that the stocks either currently exist or previously had existed. It is likely that summer chum were historically distributed among additional streams within the region. For several streams, relatively recent evidence indicates that summer chum were historically present. However, this evidence is fragmentary and judged insufficient to identify stocks. For example, one survey in Eagle Creek on September 25, 1952, reports a total of 112 chum counted in the lower 0.7 mile of the stream. Escapement surveys during the summer chum spawning period were not conducted again in Eagle Creek until 1978. Since 1978, numerous surveys during September and October have found no evidence of a summer chum salmon population.

Another example is Stavis Creek, where a survey count of 45 live and 30 dead chum salmon was made October 18, 1972. Were these fish (at least a portion of them) summer chum, or early returns of the fall run? In the same stream, over several later years (1977, 1981, 1983), a few summer chum (counts of four or less) were observed in late September and early October. It is not known whether these fish represent the last of a summer population that formerly existed, are strays from another stream, or possibly are early returns of fall run fish. Similar kinds of observation also exist for Little

Lilliwaup and Fulton creeks in Hood Canal, and Morse and Johnson creeks in the Strait of Juan de Fuca.

The identification of the above streams as possibly being part of the historic distribution of summer chum salmon is based on limited information that happened to be collected for these streams. Other streams that were not surveyed may also have supported summer chum at one time; e.g. Seabeck Creek. Absent the evidence, the specific possible historic distributions noted here, as well as any additional distributions that might be suggested for other streams, must fall into the category of unknown, but possible, former occurrences of summer chum salmon. The assessment of the historic use of these streams by summer chum salmon could change as more information becomes available.

The question of summer chum having existed in Big and Little Mission creeks has been reexamined during this process. In both streams, and particularly in Big Mission Creek, chum salmon have been observed in early to mid October and even in late September. The numbers in Big Mission appear relatively large with counts in the tens and even over one hundred by mid October in some years. However, a fairly large "early fall run" (as categorized by WDFW) exists in these two streams, with peak spawner abundance typically observed in early November. The annual survey counts of live chum typically rise steadily over the course of the season from the initial observations of fish entry in late September to mid-October, until the early November peak spawning activity period. There is no "bi-modality" in the survey counts through time that would indicate the possible existence of a discrete "summer timed" spawning population in these streams prior to the November peak timed spawning population. Genetic sampling indicates these populations are most closely associated with Hood Canal fall chum stocks.

1.7.3 Annual Abundance Evaluation

Annual abundance evaluations will be performed for both management units and stocks. Management units are made up of one or more stocks that are aggregated in recognition of practical and biological limitations to available data and how fisheries can be effectively managed (see section 3.5.2). In the case of HC-SJF summer chum, all of the management units contain only one stock except the Mainstem Hood Canal Management Unit.

Critical status[1] thresholds are defined for management units, for both total run size and spawning escapement, and critical status flags are defined for the stocks within the Mainstem Management Unit (Tables 1.9 and 1.10) below which additional actions will be taken as necessary (see sections 3.6.1 and 3.5.6.2). A description of the derivation of these thresholds is included in Appendix Report 1.5.

1.7.3.1 Management Units

[1] Note that "critical status" in the context of annual abundance evaluation is a different definition and application (as described) than the definition and application for SASSI stocks shown in section 1.7.2.

Numerical abundance and escapement thresholds have been derived for each management unit against which the post-season estimates of run size and escapement and the pre-season forecast parameters will be compared in annually assessing plan performance (Table 1.9). A management unit is considered to be in critical status when its abundance or escapement in the most recent past return year is less, or its forecast run size for the coming return year (or that of one of the parental broods) is projected to be less than the appropriate threshold value.

Table 1.9. Critical Thresholds for Hood Canal and Strait of Juan de Fuca Management Units.

Management Units	Contributing Stocks	Critical Escapement Thresholds	Critical Runsize Thresholds
Sequim Bay	Jimmycomelately	200	220
Discovery Bay	Snow/Salmon	850	930
Mainstem Hood Canal (Hood Canal Bridge to Ayres Point)	Lilliwaup Hamma Hamma Duckabush Dosewallips Total	2,660	3,980
Quilcene/Dabob Bays	Big/Little Quilcene	1,110	1,260
SE Hood Canal	Union	300	340
Total		**4,750**	**5,400**

1.7.3.2 Status of the Mainstem Hood Canal Management Unit

Escapement Distribution and Minimum Escapements Flags for each of the stocks within the Mainstem Management Unit have been derived which are designed to protect the population structure within this management unit (Table 1.10). The Escapement Distribution Flags (EDF) are mean historical threshold proportions of the Mainstem escapement, attributed to each of the contributing stocks. The Minimum Escapement Flags (MEF) have been calculated by multiplying the Critical Escapement Threshold for the Mainstem Management Unit by the EDF for each of the stocks. These flags are useful benchmarks to check for poor performance of any one stock's escapement based on historical distribution of stock escapements within the Mainstem Management Unit. This is necessary for years when the overall management unit abundance is sufficiently high that the Critical Abundance Threshold would not be triggered but escapement of one or more individual stocks may be extremely low. If a given stock's proportion of the Mainstem Management Unit escapement or the stock's actual estimated escapement fall below the values in Table 1.10, a review of the stock's status will be conducted. The conclusions from the review will be documented and its recommended actions will be implemented as described in section 3.6.1. An example of how the Mainstem Management Unit threshold and escapement flags function when they are applied to abundances of past years is shown in Appendix Report 1.5.

Table 1.10. Critical Status Flags for stocks making up the Mainstem Hood Canal Management Unit.

	Escapement Distribution			
	Mean Proportion of MU total	**1 Standard Deviation**	**Distribution *Flag* (Mean-1 SD)**	**Min. Escape. *Flag***
Dosewallips	0.277	0.130	0.147	736
Duckabush	0.263	0.083	0.180	700
Hamma Hamma	0.392	0.199	0.193	1,042
Lilliwaup	0.069	0.026	0.043	182

1.7.4 Stock Extinction Risk

1.7.4.1 Introduction

The level of extinction risk of summer chum populations (assuming no intervention) can be a primary factor for determining priorities for recovery planning. Unfortunately, there is not consensus on how to conduct a risk assessment, or on an easy way to calculate a threshold abundance level that should trigger certain levels of recovery effort. Ideally, a risk assessment would consider all factors that potentially could lead to the loss of a stock or a group of stocks. For example, a recent paper by Lee and Rieman (1997) lists eleven different factors used to develop a viability assessment procedure. These are: number of eggs per adult female, spawning and incubating success, fry survival at low density, asymptotic parr capacity, juvenile survival, adult survival rate, age at maturity, coefficient of variation in fry survival, mean immigrants per generation, initial number of adult females, and expected time between catastrophes. Most of these factors have not been quantified for summer chum salmon, or most other wild salmon populations. Given the lack of consensus on levels for extinction risk, many assessment approaches use a judgement on whether or not the population is likely to recover without intervention. This has been the approach used by NMFS in the chum status review (Johnson et al.1997).

A threshold number for extinction risk has been presented by Nehlsen et al. (1991). They consider a population under 200 (or if abundance has declined and is continuing to decline) to be at high risk of extinction. NMFS, in the chum status review, does not present any specific threshold numbers, but relies on abundance trends and abundance relative to historical levels. Allendorf and Ryman (1987) recommend that at least 100 of each sex be used to maintain a hatchery strain (again, a 200 fish value).

Two measurements of population size that are used to consider extinction risk are total population size *(N)* and effective population size *(N_e)*. Total population size is the number of spawners cumulated over a number of years equivalent to one generation (3.6 years for summer chum salmon). The effective population size is a lower value that provides an estimate of the number of spawners that represent successful reproduction and considers such factors as; sex ratios, prespawning mortality, fertility rates, etc. Effective population size is equivalent to the total population size times a factor representing the ratio between effective *(N_e)* and total *(N)* population size. There has been much discussion about the relationship of the total population size to the realized effective population size (N_e/N). Pacific salmon effective population size has been variously estimated to be from 10% to 25% of total population size. Allendorf et al. (1997) assume a N_e/N value of 20% for wild Pacific salmon populations, based on the authors' personal communications with Robin Waples (NMFS).

Measurements of Population Size

Total population Size (*N*): ***The total population size for summer chum can be calculated; N = Average escapement times 3.6 (generation length), where 3.6 is the average age of Hood Canal summer chum salmon.***
Effective Population Size (N_e): ***The effective population size per generation is equivalent to the effective number of breeders per year times the generation length (from Waples 1990). This can be calculated; N_e = Average escapement times 3.6 (generation length) times 0.2 (N_e/N).***

Effective population values of 50 and 500 fish have been suggested as threshold criteria for extinction risk. Allendorf and Ryman (1987) report that less than 1 % of the genetic variation is lost each generation if N_e is greater than 50. That is because the rate of loss of genetic variation is equal to the inverse of 2 times N_e. It has also been suggested that the long-term adaptive potential of an isolated population (without migration into it) is conserved when N_e is on the order of 500 individuals (FAO - UN 1981, Nelson and Soule 1987).

Allendorf et al. (1997) present a set of procedures for rating extinction risk and for providing an estimation of the possible consequences of extinction for Pacific salmon stocks. The methods for estimating extinction risk use either population viability analysis (PVA) or a set of surrogate measures that include current population size parameters and population trends. Allendorf et al. (1997) have also looked at the consequences of extinction on a genetic and evolutionary basis, and have considered potential loss of adaptive genetic diversity and ecological function.

The following risk assessment for summer chum stocks uses the procedures for measuring extinction risk as presented by Allendorf et al. (1997). It is recognized by the co-managers that this methodology does not include all potential risk factors (as discussed in Wainwright and Waples 1998), however, the use of both minimum population size and population trend criteria does provide a basis for ranking extinction risk. From a practical point of view, much of the information needed to assess additional sources of extinction risk is either not available or is subject to a variety of interpretations. For example, if the amount or quality of available habitat has been severely impacted, this could impose a limitation on one or more life stages and increase risks of extinction. The process for prioritizing the consequences of extinction from Allendorf et al. (1997) has not been used in this recovery plan because the co-managers consider avoidance of extinction to be of equal priority for all summer chum stocks.

The co-managers will periodically review summer chum salmon extinction risk, because these risks can change over time as a consequence of actions taken under this plan, or because of natural or unanticipated variations in survivals.

1.7.4.2 Assessing Risk

The methods provided by Allendorf et al. (1997) to assess extinction risk, result in the ranking of individual stocks into one of four categories; very high, high, moderate, and special concern (Table 1.11). They present specific definitions of various measures of population size and decline that are summarized below, and are used in the summer chum risk assessment. For the purposes of this assessment, a “low” category has been added for defining stocks that do not fit any of the above categories and are not at risk of extinction.

Population Viability Analysis

While the risk of extinction can potentially be determined by a quantitative population viability analysis such as those described by Emlen 1995 or Ratner et al. 1997 for chinook salmon, the data do not exist to conduct this type analysis for summer chum salmon. For a detailed discussion of the use of PVA and the quantitative criteria used below, see Allendorf et al. (1997).

Population Size Criteria

Allendorf et al. (1997) offer several precautions for the use of salmon spawner census numbers. First, that N represents spawning fish, not total run size, and is not an annual escapement value but is calculated by multiplying annual escapement by generation length. Second, the population numbers should account for any contribution to spawning by precocious males (not generally applicable for chum salmon). Finally, if only census numbers are available to rank extinction risk, either N_e or N can be used, but not both.

Population Decline Criteria

Each of the following criteria represent a specific risk category (see Table 1.11).

> ***Precipitous Decline*** - *A stock that has undergone recent decline (within the last two generations) to annual escapements below 500 fish, and has a recruit/spawner ratio of less than one. Historically small but stable stocks are not included in this category.*
>
> ***Chronic Decline or Depression*** - *A stock whose annual escapements are at or below 500 fish and appears to be stable, but has previously declined more than can be accounted for by known variation.*
>
> ***Decline Apparent or Probable*** - *A stock whose annual escapements have not reached the above thresholds, but, after allowing for known variation, appear to be declining at about 10% to 20% per year over the last 2 to 4 generations.*

__Order of Magnitude Decline Within One Generation__ - A stock whose escapement numbers are reduced quickly and dramatically (by catastrophic event or disturbance) by an order of magnitude in a single generation (i.e., a 90% decline).

__Smaller But Significant Decline__ - A stock that suffers a lesser but significant reduction in escapements due to a single event or disturbance.

Table 1.11. Criteria for assessing the level of risk of extinction for Pacific salmonid stocks (from Allendorf et al. 1997).

	Risk of extinction			
Risk of extinction criteria	*Very high*	*High*	*Moderate*	*Special Concern*
Probability using population viability analysis	50% within 5 years	20% within 20 years	5% within 100 years	Historically present, believed or known to still exist but no current data
	-- OR -- any **TWO** of the following criteria	-- OR -- **ONE** very high risk criterion -- OR -- any **TWO** of the following	-- OR -- **ONE** high risk criterion -- OR --	Not applicable
Effective population size per generation	N_e 50 or less -- OR --	N_e less than 500 -- OR --	Not applicable	Not applicable
Total population size per generation	*N* 250 or less	*N* less than 2500	Not applicable	Not applicable
Population decline	Precipitous decline	Chronic decline or depression	Decline apparent or probable	Not applicable
Catastrophe, rate and effect	Order of magnitude decline w/in one generation	Smaller but significant decline	Not applicable, stocks rate at least high risk	Not applicable

Risk Assessment

The following risk assessments are based on the criteria described above in Table 1.11, and the results of the risk assessments are summarized in Table 1.12.

Union River

Estimated escapements to the Union River show no declining trend over the period of record and, in fact, appear to have increased somewhat since the 1970s. This population has shown more stability than any other stock in the region. This is not to say that the size of the population has not been larger prior to the period of record; the river may have been impacted by human developments affecting habitat conditions in the earlier part of the twentieth century or even in the latter part of the previous century, and consequently run sizes have been reduced. Escapements over the last four years have ranged from 223 to 721, averaging 462 spawners. The effective population size (N_e) equals 333 for the 1995-98 return years, and total population size (*N*) is 1,667 fish for the same years

(Table 1.12). This stock meets only one high risk criterion (population size), and the risk of extinction is rated as moderate.

Lilliwaup Creek

Estimated escapements to Lilliwaup Creek range from 4 to 79 over the last four years, averaging only 33 spawners. This is 3.5% of the annual average 937 spawners estimated for the years 1974 through 1978 (i.e., from the first year of relatively reliable estimates to the year before the general summer chum escapement decline in Hood Canal; see Part Two - Region-wide Factors for Decline). The effective population size *(N_e)* equals only 24 fish for the 1995-98 return years, and total population size *(N)* is 120 for the same years (Table 1.12). Because the population meets one very high risk criterion (low population size) and is in a chronic decline situation, the risk of extinction is judged to be high.

Hamma Hamma River

The annual average estimated Hamma Hamma system escapement over the past four years is 374, ranging from 104 to 774 spawners. The wide range of escapements extending back to the mid 1980s, and dipping to less than 100 spawners in some years, raises questions about the stability of the population, however, average escapement has increased in recent years. The average of 374 spawners is 7% of the 1974 through 1978 average of 5,465 spawners. The effective population size *(N_e)* equals 269 fish for the 1995-98 return years, and total population size *(N)* is 1,347 for the same years (Table 1.12). Because the population meets one high risk criterion (population size) and is currently increasing, the risk of extinction is judged to be moderate.

Duckabush River

The estimated escapement in the Duckabush River ranges from 226 to 2,650 over the last four years, averaging 1,044 spawners. This average is 32 % of the 1974 through 1978 annual average of 3,254 spawners. The effective population size *(N_e)* equals 752 fish for the 1995-98 return years, and total population size *(N)* is 3,758 for the same years (Table 1.12). Though escapements have declined substantially since the 1970s, the current escapement levels appear to be relatively stable and this stock exceeds the population size criteria, indicating that the risk of extinction is low.

Dosewallips River

The 1974 through 1978 annual average escapement is 2,846 spawners, ranging from 1,901 to 3,593. The escapement numbers decrease substantially during the 1980s, dropping below 200 spawners in five of ten years. However, since the early 1990s, the numbers have rebounded and, over the last four years, escapement estimates have ranged from 47 to 6,976, averaging 2,537 spawners (89% of the 1974 through 1978 annual average). The estimate of 47 spawners in 1997 is a cause for concern, but this may be an aberrant year within the recovery period. The effective population size *(N_e)* equals 1,827 fish for the 1995-98 return years, and total population size *(N)* is 9,133 for the same years (Table 1.12). Because escapements have increased substantially in recent years and exceed the population size risk criteria, the risk of extinction is judged to be low.

Big/Little Quilcene Rivers

Escapement estimates averaged 1,689 spawners (range of 795 to 2,978) in the Big Quilcene River and 918 spawners (range of 44 to 1,816) in the Little Quilcene River from 1974 through 1978. For the last four years (1995-1998), the Big Quilcene River's average estimated escapement is 5,523 spawners (range of 2,244 to 8,479) while the average of the Little Quilcene River is 153 spawners (range of 29 to 265). The combined total effective population size (N_e) equals 4,087 fish for the 1995-98 return years, and the total population size (N) is 20,434 for the same years (Table 1.12). The most recent estimated returns (1995-1996) likely have been affected by the existing supplementation project begun in 1992. Based on an increasing escapement trend and the large recent escapements, the current extinction risk for this stock is low.

The risk of extinction and its effect on the decision to supplement this stock beginning in 1992, is probably best judged by examining escapements just prior to initiation of the supplementation project. The four year average estimated escapement from 1988 through 1991 is only 89 spawners for this stock (including both Big and Little Quilcene rivers), with annual escapements ranging from 2 to 297 fish. The effective population size (N_e) equals 64 fish for the 1988- 91 return years, and total population size (N) is 320 for the same years (Table 1.12). Habitat conditions in both streams are poor and represent a threat to the survival of the stock. At the time supplementation was begun, this type of risk assessment would have rated this stock to be at high risk of extinction because the high risk criteria for population size and chronic decline were exceeded.

Snow/Salmon Creeks

From 1974 through 1978, escapement estimates average 584 spawners (range of 327 to 818) in Snow Creek and 831 spawners (range of 512 to 1,664) in Salmon Creek. During the last four years, Snow Creek's average estimated escapement is 70 spawners (range of 25 to 160) and the average of Salmon Creek is 768 spawners (range of 538 to 1,023). The total average escapement for the stock in the last four years is 838 spawners, with a range of annual escapements between 563 and 1,051 fish. The effective population size (N_e) equals 603 fish for the 1995-98 return years, and total population size (N) is 3,017 for the same years (Table 1.12). The most recent return estimates (1995-1998) likely have been affected by returns to the existing supplementation project begun on Salmon Creek in 1992. Since the stock (with two streams combined) has experienced increasing overall escapements in recent years and average escapement exceeds the population size risk criteria, the current risk of extinction is judged to be low.

As with the Quilcene stock, the risk of extinction and its affect on the decision to supplement this stock should be judged by examining escapements just prior to initiation of the supplementation project in 1992. The four year average estimated escapement from 1988 through 1991 is 829 spawners for this stock, with annual escapements ranging from 184 to 2,638 fish. The four-year average is heavily influenced by the 1988 escapement of 2,638 spawners, however, the three subsequent years (1989 - 1991) have an average escapement of only 226 fish, with a range from 184 to 278 spawners. Using the 1989 to 1991 three year average of 226 fish, the effective population size (N_e) equals 163 fish, and total population size (N) is 814 for the same years (Table 1.12). Habitat impacts are moderate to high and potentially are a threat to the survival of the stock. At the time supplementation was begun, this type of risk assessment would have rated this stock to be at high risk of extinction, because the very high risk criterion of precipitous decline and the high risk criterion for population size were exceeded.

Jimmycomelately Creek

Escapements for Jimmycomelately Creek for the past four years annually have averaged 103 spawners (range of 30 to 223). Sufficient in-stream spawner survey data to estimate escapement have not been collected on Jimmycomelately Creek before 1982. However, for the seven year period of 1982 through 1988 (the latter year being the start of the general decline for Strait of Juan de Fuca stocks), annual escapement estimates average 441 spawners (range of 61 to 1,052). The recent four year average is 23% of the historical seven year average. The effective population size (N_e) equals 74 fish for the 1995-98 return years, and total population size (N) is 371 for the same years (Table 1.12). Because of the chronic decline of this stock and population sizes meeting the high risk criteria, the risk of extinction is judged to be high.

Dungeness River

Historically, surveys of summer chum spawners have not been performed in the Dungeness River and no escapement estimates are available. Only recently has it been recognized that summer chum persist in the river. This information comes from observations made in the course of collecting data on chinook and pink salmon as part of ongoing recovery efforts for these two species. Habitat conditions are relatively poor and may pose a threat to the summer chum stock. Little information is available through which judgements can be rendered regarding the status of the Dungeness stock, if it exists. More information is needed before recovery activities are contemplated and the Dungeness River stock risk rating is special concern.

Table 1.12. Extinction risk assessment for summer chum salmon (based on Allendorf et al. 1997).

Stock	Escapement (Mean 95-98)	Effective Population Size (N_e) [1]	Total Population Size (N) [2]	Recent Population Trend	Risk Rating
Union	462	333	1,667	Increasing	Moderate
Lilliwaup	38	27	137	Chronic decline or depression	High
Hamma Hamma	366	264	1,318	Increasing	Moderate
Duckabush	1,044	752	3,758	Increasing	Low
Dosewallips	2,537	1,827	9,133	Increasing	Low
Big & Little Quilcene					
Current status	5,676	4,087	20,434	Increasing	Low
Pre-project status	89 [3]	64	320	Precipitous decline	High
Snow/Salmon					
Current status	835	601	3,006	Increasing	Low
Pre-project status	226 [4]	163	814	Precipitous decline	High
Jimmycomelately	103	74	371	Precipitous decline	High
Dungeness	No data	Not available	Not available	Not available	Special Concern

[1] Effective population size (N_e) = Average escapement x 3.6 (generation length) x 0.2 (N_e/N).
[2] Total population size (N) = Average escapement x 3.6 (generation length).
[3] Big/ Little Quilcene average escapement for 1988 through 1991 return years.
[4] Snow/Salmon creeks average escapement for 1989 through 1991 return years (see text).